F E A S I B I L I T Y S T U D Y

OF

HEAT PUMP VS. EXISTING AIR CONDITIONING/HEATING SYSTEM IN

RESIDENTIAL QUARTERS

STAT

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1. This study is intended to describe the relative advantages and disadvantages of refrigeration heat pumps versus the characteristics of forced hot air oil fired furnaces and summer utilized window model refrigerant air conditioning units currently installed at the [redacted] residential quarters. STAT The information presented is not intended to be inclusive of all mechanical/electrical engineering details; but should supply sufficient criteria to determine the feasibility and cost effectiveness of conversion from the existing furnaces and refrigerant air conditioning window units to heat pumps. Fundamental engineering data, maintenance postures, cost experience/quotations and other pertinent information is provided to assist in developing summary conclusions and comparative evaluations.

2. HISTORY. There are three distinct types of [redacted] STAT

STAT housing located [redacted] (see Attachment #1). Although the styles are very similar; they differ essentially in floor plan, room layout and square footage. Specifically, they are three bedroom duplexes, three bedroom detached and four

STAT bedroom detached. [redacted] quarters were constructed

STAT [redacted] and [redacted] were completed in 1962; for

STAT a total of [redacted] residences. Original design of the heating system installed all [redacted] with a STAT forced air, fuel oil fired, furnace, supplied from individual two hundred and fifty gallons in ground, fuel oil tanks located in proximity with the residence. The oil burner provides fan blown hot air through a series of under slab ducts, re-

leasing the warmed air through strategically located base board exhaust registers. The warm air in thermostatically controlled by a living room, wall mounted thermostat, (single zone). The three bedroom detached and duplexes all had 85,000 BTUH (850 CFM) furnaces installed in original construction while the four (4) bedroom homes had a 112,000 BTUH (950 CFM) furnace installed. Public Works records indicate that twelve (12) furnaces have been replaced in the last eight years; seven of the twelve were in the last five years. Eleven (11) fuel oil tanks have been replaced in the past six years due to rust deterioration and subsequent leaks.
STAT All [redacted] residences also have living room fireplaces.

In 1972 a program was developed to install 18,000 BTUH window type refrigerant air conditioner units in the living
STAT rooms of all [redacted] residences. After the completion of this project it was found to be only marginally effective as a summer time climatization. Consequently, in 1974 an additional 8,500 BTUH window unit was added in the master bedrooms. The combination of the two air conditioning units were then utilized to supply the entire residence with summertime cooling.

3. FURNACE MAINTENANCE AND OPERATIONAL COST DATA. Furnace maintenance and operations costs are predicated on usage. Consequently, to determine an annual cost, heating degree days are used for the annual average. Heating degree days are the mean annual number of degree days using a base of 65° Fdb and a 30 year period to develop the average normal.

From data collected (attachment #3) [redacted] STAT

STAT [redacted]

the heating season occurs October through April. This equals a total average of 3671 heating degree days/30 years or 122 days/peryear. Average individual [redacted] fuel oil consumption for this annual period is 550 gallons which represents $473/annum at the current price of *$.86 per gal. (This, incidentally represents a 84% increase since 1973). Further price increases are being experienced at this facility. Overall furnace maintenance which includes yearly cleaning, incidental parts replacement, furnace assembly replacement costs, labor, etc., averages $122 per year. This total annual furnace operating cost of $595 does not reflect the aging condition of the residential heating plants, which is evidenced by the increasing frequency of furnaces and fuel oil tanks that require replacement and does not include electrical consumption used by the furnaces.

4. WINDOW AIR CONDITIONER MAINTENANCE AND OPERATION COST. Criteria used to develop these costs is data of the number of hours, on the average, that existing window units are operational. This is determined by using the latitude and longitude provided in Para. 3 and averaging the hours that the drybulb temperatures of 93°F and 80°F and the wetbulb temperatures of 73°F and 67°F are equal or exceeded

* November bid quotation for DSA fuel oil contract price has been quoted at $.94 per gal.

during the warmest six (6) consecutive months as determined from the monthly mean wetbulb temperature. For

STAT [redacted] these months have been standardized as May through October, even though on occasional years November was warmer than May and April was colder than October. In any event, the statistics for these months indicate:

*Drybulb

over 93°F - 42 hours

over 80°F - 932 hours

*Wetbulb

over 73°F - 807 hours

over 67°F - 2065 hours

This indicates a total of 1781 seasonal operating hours on each air conditioner. Assuming both units are not always operating simultaneously, it appears reasonable to estimate 75% of two running units, i.e...

1781 operational hr. per unit
1781
3562 total operational hr/two unit/residence

*Note: Both wetbulb and drybulb have to be considered when dealing with desirable body comfort.

75% x 3562=2871 average seasonal hrs/residence

The two units draw 3750 watts (typical)

$3750 \times 10^{-3} = 3.75$ KW

3.75 x 2871 = 10,766 total seasonal KWH

10,766 x .035 (cost KWH) = $377.00

Consequently, $377.00 equals average annual electrical cost per residence each year for electrical operation of the window a/c units. Maintenance cost for the window units is reflected by labor, parts, replacement and unit replacement. Records indicate these costs to be $167.00 each annum per residence. There are significant trouble calls for problems of vibration, thermostats, capacitors, compressor lock-ups etc., that justify this high cost maintenance. There also are the numerous man hours expended covering the units in winter time and uncovering in late spring. In any event the total cost of summer time cooling of the residences through use of the window type refrigerant unit is $544.00/yr/qtrs. Consequently, annual climitization of each residence is ($595 winter) plus ($544 summer) equaling $1,139 per residence each year. (Not inclusive of electricity cost for furnace operation).

5. HEAT PUMP. All refrigerant units are heat pumps. They all move heat from one place and transfer it to another. They all pickup heat at low temperature level and release it

at high temperature level. The cooling coil and condensors are both heat transfer devices and they can each be used for both cooling or heating. The heat pump is also incorrectly called a reverse cycle air conditioner. This is not actually correct since the cycle is not reversed; but only the cooling coil and condensor air is interchanged. The heat pump will remove heat from an occupied space and discharge this heat to the outside, or it can be used to pick up heat from the outside and discharge it into occupied space to heat it.

6. HEAT PUMP APPLICATION IN CAPEHART QUARTERS. In efforts to take advantage of existing design features of the heating

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system of the [redacted] quarters, a split type heating, ventilating, air conditioning total system would be provided. The condensor fan coil w/compressor unit would be mounted outdoors in a direct line proximity with the existing furnace room. The oil fired furnace would be removed and replaced with a down flow vertically mounted evaporator fan coil unit supplemented with a 15 KW two stage electric heater located in the plenum. This combination unit would then cool the residence in warm/hot weather and heat it during cold weather. This is accomplished by using automatic two-way valves in the refrigerant lines allowing the evaporator or cooling unit to be changed to a condensor for winter operation. The cooling cycle operates as any conventional refrigerant air conditioner while the heating cycle consists of removing heat from the outside ambient air and releasing this heat in the house, In this way, the heat pump system puts the weather to work by taking advantage of the fact that even cold air contains solar heat that can be recovered for indoor use. This approach means that typically 2 units of energy (heat) are received for every unit of energy (electricity) used by the heat pump system. The result is lower system operating costs and lower fuel usage.

During winter however, the heating cycle becomes less efficient as the outdoor temperature lowers. This action plus the increase in load as the outside temperature lowers offers more difficulty in the heat pumps application. For this reason an electric two-stage heater would be included in the plenum of the down draft evaporator fan coil unit. This forced hot air will then supplement heat during those heat degree days where the inside residence temperature is not entirely satisfied with the heat pump output. In summer or winter the indoor unit will utilize the existing supply and return duct system currently in an "as built" situation. There will also be no change of space requirement in as much as the existing furnace area is more than adequate for installation of the indoor evaporative fan coil unit w/supplemental electrical heater.

7. HEAT PUMP CALCULATIONS. Summarized criteria as previously defined in Para 3 and 4 indicates [redacted] STAT received 2928 heating hours per average year, 1781 air conditioning hours per average year, which leave a remaining 4051 average yearly hours where alledgedly no residential climatizing is necessary. Assuming whatever type of unit used to climatize the quarters is thermostatically controlled, these figures are realistic and practical. This established; a calculation for a heat pump may be sized by multiplying the "U" factor (amount of heat transferred through the residential structures) by the various loads contributing to the areas to be climatized. The "U" values obtained for these calculations are from tables supplied by the "American Society of Heating Refrigerating and Air Conditioning Engineers" and reconfirmed by original calculations (see attachment #2). Consequently, total average load requirement is 44,836 BTUH, or given 12,000 BTUH=1 Ton, the recommended procurement would be each 3.7 ton split type heat pump unit.

A preliminary cost quotation for procurement and installation of this split type heat pump, with accessories, to climatize one individual residence year round is $3,900. This cost reflects specific identified electrical features not itemized in this study, but nevertheless included to support the installation. Using temperature criteria (attachment #3) and other pertinent weather information established in previous paragraphs, the following operational cost data is made available:

1781 a/c hr/yr
1781 hr/yr x 3.7 KW=6589 KWH/yr
6589 x .035 = $230 per annum cooling
2928 heat hr/yr
2928 x 3.7 KW=10,834 yr/KWH
10834 x .035=$379 per annum heating

Of the 2928 heating hours a year, there are a 30-year average of 911 hours where the outside ambient temperature is below 34°Fdb. During this period, the supplemental two-stage, 15 KW heater maybe required part-time to satisfy the indoor thermostat demand. Hence, considering the two-stage electric heater and heat pumps effectiveness, it appears practical to use 1/5 of the total 15 KW capacity for the full 911 hours.

1/5 of 15 KW=3 KW

3KW x 911 hrs = 2773 KWH

2773 KWH x .035 = $97.00 cost of 2-stage electric heater accessory operation

8. COST COMPARSION. A summary anaylsis of investment and operating costs:

Existing operation per residence per year

Fuel Oil	$473.00
*Furnace Maint/Replacement	122.00
Window A/C unit usage	377.00
Replacement A/C (window)	167.00

Existing total annual cost $1,139.00

* This figure will rise considerably as the number of aging heat plants are replaced and does not include an overall

amortized cost of new furnaces except in maintenance.

Cost of proposed yearly heat pump operation per residence.

10 year amortized cost of heat pump		$ 390.00
summer operation		230.00
winter normal		379.00
winter heater supplement		97.00
	TOTAL	$1,096.00

On the other hand, the future of the heat pump looks bright. The increased generation of electric power using nuclear and solar fuels all indicate a greater expansion of this type of system. [redacted] receives approximately 70% of electricity sourced [redacted] which are both in the immediate area. Fuel oil cost of $.86 per gallon vice the $.035/KWH cost for electricity is out of proportion. This low electrical residential KWH cost is the result of [redacted] falling under the umbrella [redacted] which allows the entire [redacted] to benefit from the lowest possible industrial rates which are roughly equivalent to three (3) times less costly than civilian residential rates. In todays inflation susceptible market it is evident every commody is rising in cost; however, the indications are that electricity costs have not, and will not keep the rising pace of petroleum costs. The centralized climatizing features of the heat pump will also take year-round advantage of the existing duct system, thereby providing more efficient annual temperature/humidity control through out the entire residence.

The electrical cost for operating the oil burner motor, the ignition transformer, and blower for the forced warm air has not been included in this study. This cost, although not very significant, plus the undisclosed amortized replacement costs of new furnaces and new window units versus the already identified capitol investment of the heap pump all indicate the heat pump is economically justified when the fixed charges are spread out for year-round air conditioning system in summer and heating in winter. This economic justification is enhanced by the availability of the existing duct design and existing space where the evaporator fan coil would be located in place of the furnace. One other item which is of a no cost value but is nevertheless a feature worth identifying is: the existing centrally located furnace room with a louvered full size entrance door creates a considerable resident noise factor during ignition and fan operation. This undesirable noise nusience would virtually disappear with the furnace removal and subsequent heat pump installation.

It is the recommended conclusion of this study that a program be developed to phase in the installation of heat pumps in the quarters.

CONCLUSIONS

In the foregoing paragraphs many items have been presented for consideration to provide an intelligent, practical solution for choice of selection between heat pump installation or continued utilization of the present arrangement for heating/cooling in the [redacted] quarters. We are aware STAT that the residences have an oil-fired furnace system that is in an aging condition. Consequently, it is inevitable that maintenance costs and heating unit assembly replacement will become increasingly more demanding. Also, with the possibility of depletion, or at best reduction, of present fossil fuels, the future availability does not look bright. At minimum, it is anticipated fuel oil price inflation will continue to rise at an accelerated pace.

The as installed cooling system using the two (2) window air conditioning units is marginally efficient as a centralized summertime temperature/humidity control and has become a maintenance nightmare of frequent and continuing trouble calls. As a result of inefficient resident ventilation supplied by the window units function, there is minimum dehumidification in summertime operation. Humidity is prevalent in this locality and a contributing factor to personnel discomfort and mildew growth. This deficiency encourages occupants to operate the two window air conditioning units simultaneously, when on many occasions perhaps only one should be operating.